HEAT ENERGY CONSUMPTION ANALYSIS IN RIGA CITY NOT RENOVATED PUBLIC BUILDINGS AND IN BUILDINGS AFTER PARTIAL RENOVATION

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Abstract. The aim of the research was to analyze the heat energy consumption in public buildings managed by the Riga City Municipality in the year 2008. The collected information contains the data about more than 400 not renovated buildings and buildings after partial renovation: windows condition, heat energy consumption, electric energy consumption in the heating season and warm season, ventilation total power with and without air conditioning systems. The data were analyzed dividing all public buildings in twelve groups. They are: schools, special status education schools, academy of music, day-care centres, hospitals, libraries, cult buildings, recreation centres, local government buildings, museums, sport centres and shelters. Our analysis focused on the heat energy consumption in: a) not renovated buildings with simple windows divided in two-panes with two separate wooden frames with the heat transmittance $U \geq 2.5$ $W \cdot m^{-2} \cdot K^{-1}$; b) partially renovated buildings with energy-efficient double-pane windows made of polyvinylchloride with the heat transmittance $U \leq 1.8$ $W \cdot m^{-2} \cdot K^{-1}$. At the beginning we compared the heat energy consumption in each building group with windows covering more than 20 % and less than 20 % of the building facades. We have analyzed the data for each group separately. Our analysis shows, that partial renovation: heat insulation of buildings with windows change in buildings does not give heat energy consumption economy, but in most part of cases made it even bigger.

Keywords: heat, energy, public buildings, schools, day-care centres, renovation.

Introduction

In the whole world energy economy and efficiency is very topical. Energy consumption economy and optimisation make smaller carbon dioxide emissions. Important decisions of The European Parliament and of the Council are: directive 2002/91/EC of 16 December 2002 – on the energy performance of buildings [1], directive 2004/8/EC of 11 February 2004 – on the promotion of cogeneration based on a useful heat demand in the internal energy market [2], directive 2006/32/EC of 5 April 2006 – on energy end-use efficiency and energy services and repealing of the Council Directive 93/76/EEC [3]. On the basis of these documents the Latvian Cabinet of Ministers made laws for local using [4-6]. The main ministry on energy issues in Latvia is the Ministry of Economics [7]. Buildings with very huge heat energy demands are a part of Latvian heritage from the Soviet times. The greatest part of public buildings has not the mechanical ventilation systems.

The indoor air quality (IAQ) after partial renovation slowly begins deteriorated because outdoor air infiltration has stopped. This unpleasantness is omitted.

Our task of the current studies was to analyse the heat energy consumption in public buildings managed by the Riga City Municipality in the year 2008.

We did not find similar studies in Latvian scientists' publications. This time we have not analysed IAQ parameters as for example described by Fromme et al. (2007) [8] and Santamouris et al. (2008) [9]. In Latvia there are similar researches as for example by Gendelis and Jakovičs (2006) [10; 11].

Materials and methods

We have analyzed the heat energy consumption in not renovated public buildings and partially renovated public buildings managed by the Riga City Municipality in the year 2008. The collected information contained the data about 422 public buildings which were divided in 12 groups: special status education schools – 43 060 m²; shelters – 9 993 m²; local government buildings – 44 077 m²; recreation centres – 59 994 m²; museums – 369 m²; hospitals – 15 232 m²; sport centres – 18 435 m²; libraries – 8324 m²; academy of music – 5 368 m²; day-care centres – 248 923 m²; schools – 866 769 m²; cult buildings – 6 067 m².

The data analysis focused on the heat energy consumption in not renovated buildings with simple windows from double glass panes in two separate wooden frames with the heat transmittance $U \geq 2.5$ $W \cdot m^{-2} \cdot K^{-1}$ and partially renovated with energy – efficient double – pane windows and frames from polyvinylchloride $U \leq 1.8$ $W \cdot m^{-2} \cdot K^{-1}$. We made two subdivided groups for each building group with window covering more than 20 % and less than 20 % of the building facades as described in like manner by Bokel (2007) [12] in each public buildings subdivided groups. Initially we have analyzed the data for each group separately as the same was performed by Krūmiņ et al. (2010) [13], but later we made our analysis of two largest groups separately not subdivided with window covering more and less than 20 %.

The research data were obtained after the heating season in spring of the year 2009. We made a special inquiry form and sent it to every public building chief managed by the Riga City Municipality. After receiving the filled in form we sorted and batched the information. Useless forms with incomplete registration were not used. After the data were batched we performed statistical analysis with simple mathematical methods.

Our data analysis based on building mathematics mean parameters were compared in each of 12 divided groups separately. We summed the floor areas of each buildings group and the total heat consumption of the year in these. Then we calculated how much heat energy was demanded for each type of the buildings one square metre of the floor. We compared the findings in not renovated buildings and buildings after partial renovation.

The outdoor air temperature parameters in the year 2008 [14] are shown in Figure 1.

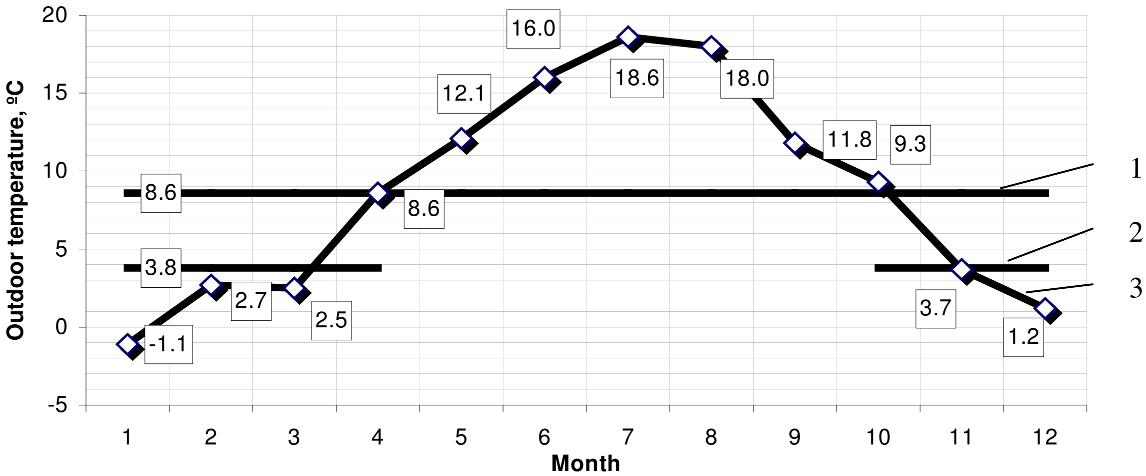

Fig. 1. **Average monthly outdoor air temperature in the year 2008 (°C):**
1 – average outdoor air temperature (°C) per annum; 2 – monthly average outdoor air temperature (°C) in the heating season, 3 – monthly average outdoor air temperature (°C)

Results and discussion

Our attention was focused on two building group results. They are day care centres (143 units analyzed) – (Table 2), and schools (158 units analyzed) – (Table 3).

We present our investigation results summary, not dividing day care centres and schools in two groups with window covering ≤20 % and >20 % of the building facades (Table 2 and Table 3).

The average heat energy consumption per annum to one square metre in not renovated buildings and in partially renovated buildings (Fig. 2) shows that partial renovation in the day-care centres is done wrongly. The average heat consumption after partial renovation increased by 18 % in the day-care centre buildings and lessened by 4 % in school buildings. The Latvian Energy Development Guidelines for the years 2007-2016 define that the heat energy consumption is decreasing by approximately 28 %. In the time period till the year 2020 the heat energy consumption must be decreasing by 40 %. For example: if now the heat energy consumption is 250 kWh·m^{-2} per annum, then in the year 2020 the heat energy consumption requires decreasing up to 150 kWh·m^{-2} per annum [7].

Table 1

Heat and electric energy consumption in day-care centres and schools

Parameter	Day-care centres	Schools
Total number of units a) not renovated b) partially renovated	143 32 111	158 56 102
Total floor areas (m^2)	248 923	866 769
Average unit area (m^2)	1 741	5 486
Heat energy total consumption (kWh) in this group of buildings per annum	53 102 920	103 783 050
Heat energy average consumption ($kWh \cdot m^{-2}$) in this group of buildings per annum	213	120
Heat energy average consumption ($kWh \cdot m^{-2}$) in not renovated buildings per annum	184	124
Heat energy average consumption ($kWh \cdot m^{-2}$) in partially renovated buildings per annum	224	118
Electric energy total consumption (kWh) in this group of buildings per annum / average - ($kWh \cdot m^{-2}$)	7 010 729 /28	20 207 679 /23
Electric energy total consumption (kWh) in not renovated buildings per annum / average - ($kWh \cdot m^{-2}$)	1 685 457 /25	6 254 041 /20
Electric energy total consumption (kWh) in partially renovated buildings per annum / average - ($kWh \cdot m^{-2}$)	5 325 272 /29	13 953 638 /25
Ventilation with and without air conditioning systems in buildings 1.Total number of units 2.Total power (kW) 3.Total power to building one square metre ($kW \cdot m^{-2}$)	 79 262 $1 \cdot 10^{-3}$	 106 1 515 $2 \cdot 10^{-3}$

Table 2

Proportion of total floor areas and total heat consumption per annum in not renovated day-care centres and in partially renovated comparing in per cents

Building groups	Windows covering ≤20 % of the building facades		Windows covering >20 % of the building facades	
	Total floor areas (8 262m²)	Heat consumption per annum (1 933MWh)	Total floor areas (240 661m²)	Heat consumption per annum (51 169MWh)
Not renovated	64	52	27	23
Partially renovated	36	48	73	77

Table 3

Proportion of total floor areas and total heat consumption per annum in not renovated schools and in partially renovated comparing in per cents

Building groups	Windows covering ≤20 % of the building facades		Windows covering >20 % of the building facades	
	Total floor areas (48 816m²)	Heat consumption per annum (6 231MWh)	Total floor areas (817 953m²)	Heat consumption per annum (97 552MWh)
Not renovated	13	12	37	38
Partially renovated	87	88	63	62

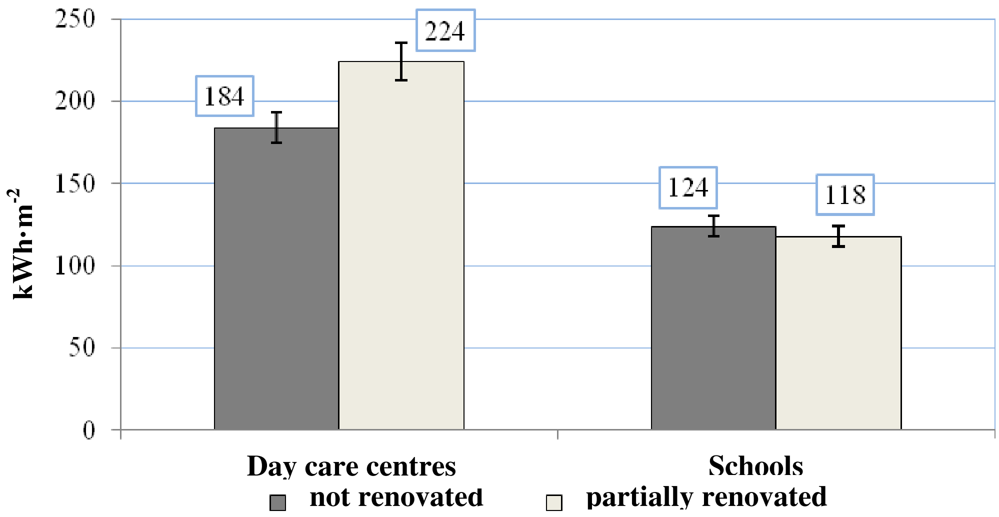

Fig. 2. **Average heat energy consumption per annum to one square metre in not renovated buildings and in partially renovated buildings with error bars with 5 % value**

The results of the heat energy consumption in not renovated day-care centre buildings and in partially renovated buildings clearly show that partial renovation did not give the stated heat energy economy. We see that the aim of partial renovation in both public building groups is not reached.

We have not representative information about IAQ in both buildings groups.

Part of IAQ parameters have taken a turn for the worse: air humidity and carbon dioxide quantity. This unpleasantness is omitted. We need to obtain, analyse and compare the IAQ parameters with the investigation results of the scientists of other countries.

In Fig. 7 the regression lines from Fig. 3 and Fig. 4 are integrated. In Fig. 8 the regression lines from Fig. 5 and Fig. 6 are integrated.

If partially renovated buildings were made under adequate information and based on scientific investigations, the regression line from partially renovated buildings must be located under the regression line from not renovated buildings. Fig. 7 clearly shows that partial renovations in buildings was done wrongly, but not in all cases (Fig. 4 and Fig. 6). Partially renovation in school buildings also was made wrongly, because the regression lines in Fig.8 have a point of intersection.

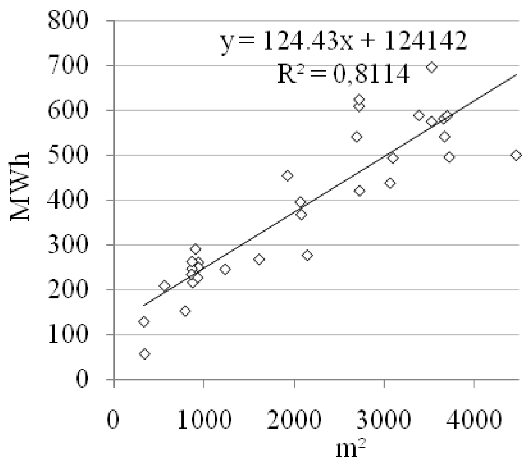

Fig. 3. **Not renovated day-care centre buildings:** total heat energy consumption (MWh) per annum buildings correlation with buildings floor area (m^2)

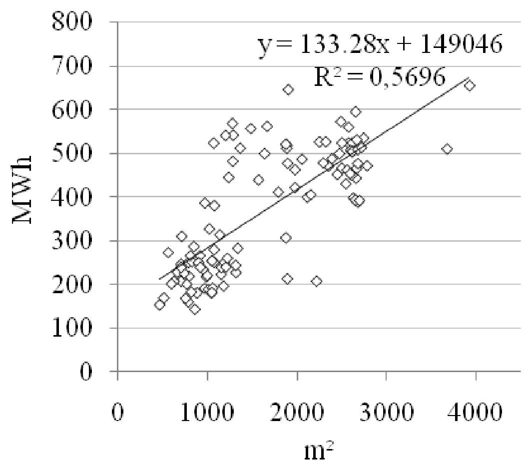

Fig. 4. **Partially renovated day-care centre:** Total heat energy consumption (MWh) per annum correlation with buildings floor area (m^2)

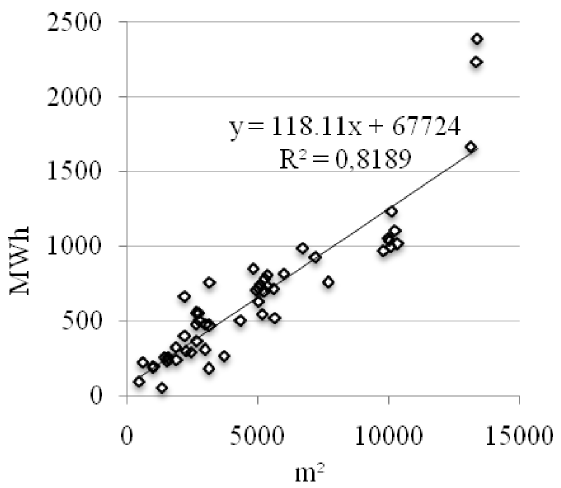

Fig. 5. **Not renovated school buildings:** total heat energy consumption (MWh) per annum correlation with buildings floor area (m^2)

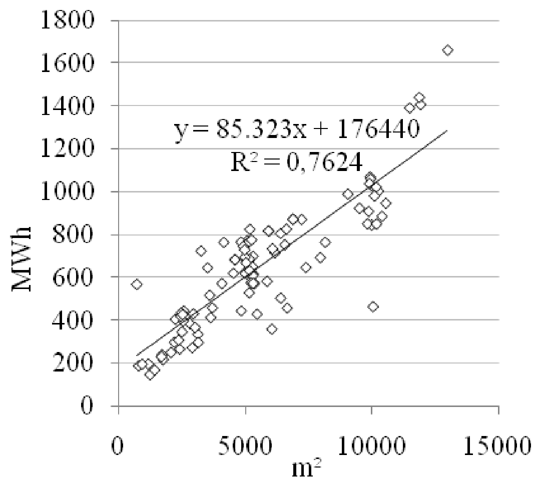

Fig. 6. **Partially renovated school buildings:** total heat energy consumption (kWh) per annum correlation with buildings floor area (m^2)

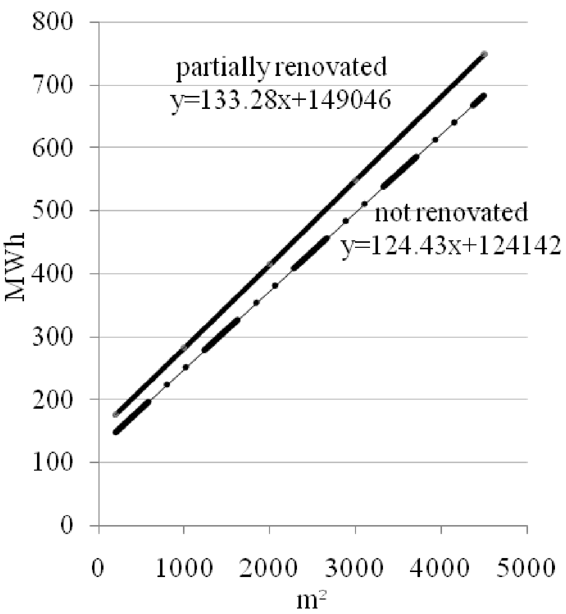

Fig. 7. **Regression lines of the day-care centres from not renovated buildings and partially renovated:** total 143 units (not renovated -32 units; partially renovated – 111 units)

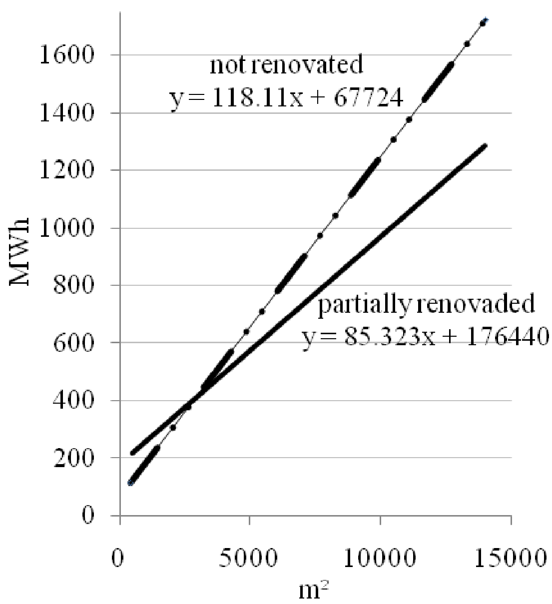

Fig. 8. **Regression lines of the schools from not renovated buildings and partially renovated:** total 158units (not renovated -56 units; partially renovated – 102 units)

Energy consumption lessening and optimisation make smaller carbon dioxide emission. Right building and renovation help to do it. Our results show, that at present in buildings partial renovation is done somehow wrong.

Conclusions

1. This direction has been explored very little in Latvian scientific researches.
2. Heat energy consumption enlarging in day care centres shows that average partial renovation is made under inadequate information. Partial renovation in school buildings on average also was done wrongly.
3. By this medium made partial renovation on average does not give heat energy lessening.

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